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ABSTRACT

This paper advocates oral communication as one of the most effective methods of improving classroom instruction in all subjects. It focuses on the teaching of mathematics and science, where the grasping of concepts is essential to student learning. The paper provides a rationale for oral communication across the curriculum. Further, the paper describes a project to provide inservice training for elementary and secondary teachers which will focus on: (1) using oral communication to enhance the teaching/learning of mathematics and science; (2) using an integrative approach to teaching/learning in the mathematics and science curriculum; and (3) using content specific personnel from the areas of mathematics and science who also have expertise and training in the use of oral communication in the teaching/learning process. The paper identifies goals, objectives, activities, and evaluation techniques for the project. Seventeen references and an appendix containing workshop evaluation statements are attached. (SR)

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ORAL COMMUNICATION TECHNIQUES TO ENHANCE STUDENT LEARNING OF MATHEMATICS AND SCIENCE IN ELEMENTARY AND/OR SECONDARY SCHOOLS

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Paper presented at the November 1990 Speech Communication Association Convention, Chicago

ORAL COMMUNICATION TECHNIQUES TO ENHANCE STUDENT LEARNING OF MATHEMATICS AND SCIENCE IN ELEMENTARY AND/OR SECONDARY SCHOOLS

Abstract

Elementary and secondary school speech communication teachers can play a leading role in enhancing learning across the curriculum. Oral language empowers thinking as well as expression. It is a key component of the language-thinking-learning connection. The use of oral communication to learn is proposed as one of the most effective methods of improving classroom instruction in all subjects. This paper provides a rationale for oral communication across the curriculum. The goals, objectives, activities and evaluation techniques of a project designed to implement oral communication to learn across the curriculum are identified to help elementary and secondary speech communication teachers develop such programs for math and science teachers in their schools.

NEED

Most proposals for improving math and science instruction emphasize content-based knowledge for teachers. This approach is laudable, but it fails to address a need which is equally important--the discovery and implementation of pedagogies which will enhance student learning of mathematics and science. One of the most promising pedagogies involves using oral communication techniques to enhance learning of mathematics and science. The Ontario Ministry of Education, one of the world's leading education authorities, provides a clear statement of the need for and value of this pedagogy.

> Language plays a central role in learning. No matter what the subject area, students assimilate new concepts largely through language, that is, when they listen to and talk, read, and write about what they are learning and relate this to what they already know. Through speaking and writing, language is linked to the thinking process and is a manifestation of the thinking that is taking place. Thus, by explaining and expressing personal interpretations of new learning in the various subject fields, students clarify and increase both their knowledge of the concepts in those fields and their understanding of the ways in which language is used in each.
>
> It follows, then, that schools should provide an environment in which students are encouraged to use

> language to explore concepts, solve problems, organize information, share discoveries, formulate hypotheses, and explain personal ideas. Students need frequent opportunities to interact in small group discussions that focus on the exploration of new concepts. In addition, they should be encouraged to keep journals in which they write thoughts, questions and speculations that reflect on their learning.
>
> Principals should provide leadership by encouraging all teachers to participate in developing and practicing a school language policy, which is, in effect, a school learning policy. By allowing students to discuss and write in the language they already control, teachers can gain new insights into the difficulties that students are encountering in particular subject areas. In this way teachers can help students to avoid rote learning and to gain clear understandings. (Corson, 1988, pp. 12-13)

The act of creating, testing, revising and communicating a message is the basis of effective education (Steinfatt, 1986). Title II of the 1978 Elementary and Secondary Education Act identifies the basic skills as "reading and mathematics and effective communication, both written and oral." Virtually every report on educational reform stresses the centrality of oral communication in the teaching/learning process (see, for example, Roberts, 1983; Boyer, 1986; Steinfatt, 1986; Weiss, 1988; Task

Force on Education for Economic Growth (Education Commission of the States), Action for Excellence, Brummett, 1987; Curtis, Winsor & Stephens, 1989; Sullivan, 1989; Ballard, 1989).

Almost every argument for employing writing to learn supports the case for utilizing oral communication to learn. It follows that schools should provide additional opportunities for students to use oral language to explore concepts, share personal thoughts, discoveries and feelings, formulate hypotheses, organize and evaluate ideas, share and solve problems and become more active and effective listeners. Additional applications of oral communication techniques as teaching/learning strategies can help students improve critical thinking/problem solving skills, thereby moving beyond rote learning in mathematics and science.

Providing elementary and secondary school teachers additional content knowledge of mathematics and science is a necessary but not a sufficient condition for improving student learning in these areas. Debate no longer exists about the role of oral communication activities in developing literacy, the intellect, problem solving skills and in acquiring knowledge. Thus, it is essential to improve the quality and expand the application of meaningful oral communication activities to enhance student learning of mathematics and science.

The report Science for all Americans points out that:

> Effective oral and written communication is so important in every facet of life that teachers of every

> subject and at every level should place a high priority on it for all students. In addition, science teachers should emphasize clear expression, because the role of evidence and the unambiguous replication of evidence cannot be understood without some struggle to express one's own procedures, findings, and ideas rigorously, and to decode the accounts of others. (p. 148)

Everybody Counts: A Report to the Nation on the Future of Mathematics Education, released in January, 1989, presents a plan for radical change in mathematics education from kindergarten to graduate school. The report stresses that "students learn mathematics well only when they construct their own mathematical understanding" (p. 58).

Unfortunately most mathematics and science teachers have not been trained in using oral communication to help students construct their own understanding (Collins, 1987 a). Many students are intimidated by their generalized fears of mathematics and/or science and by the "normal" pedagogical approach of their teachers. David Corson, a leading educational authority, highlights the effects.

> Observation confirms that middle schoolers often do not begin to understand the concepts teachers use in Math until years after they are first introduced. Sometimes the concepts are never fully grasped and the child in confusion turns away from mathematics as a result....
>
> In the sciences, as in mathematics, the technical

> language of the subjects can be a most intimidating obstacle for young children. Their grasp of specialist concepts can determine, in the long run, their success. ... Barnes is very critical of the word-teaching practices, commonly used in the sciences in particular, where "presentation" of the "technical terms" by teachers is thought to be sufficient to establish the concept for children. Conceptual learning, though, does not arise merely through "having the word"; a technical term must be inserted firmly into the related ideas and terminology of a realm of discourse by children if it is to have permanence and significance for them. This form of word-learning comes most readily not through teaching but through effective talk around the subject matter that embeds the concept. (pp. 84,87)

Evidence is accumulating to support the application of oral communication techniques to enhance student learning of mathematics and science. Although formal evaluation of learning outcomes is in the infancy stage for both oral communication and writing across the curriculum, the "results of research in the areas of metacognition, or learning awareness, and writing to learn are beginning to point to the importance of providing students the opportunity to focus on their own learning process in an attempt to make that learning be better learning" (Nocerino, 1987, p. 159).

Assessment data compiled on the oral communication activities conducted at a Southeastern university in microbiology and statistics (Spring, 1989) suggests potential benefits in elementary and secondary school mathematics and science instruction. Of university students providing a response in mathematics and science classes: 77% rated oral communication activities as good or excellent, 33% said they would have learned less without oral communication activities; none said they would have learned more, 80% either agreed or strongly agreed that such activities helped them improve their oral communication skills, 50% said the course was better due to the inclusion of oral communication activities; only one student said the course was worse.

The use of oral communication to learn, while valuable for all elementary and secondary school mathematics and science students, addresses the special needs of females, minorities, individuals with limited English proficiency and gifted and talented students. They can utilize oral communication to construct their own understandings of mathematics and science and at the same time improve their oral communication skills.

Preliminary research supports the value of training teachers to incorporate oral communication activities to enhance student learning in classes across the curriculum. Speech communication teachers in elementary and secondary schools are encouraged to approach their administration, colleagues and funding sources such as the Dwight D. Eisenhower Mathematics and Science

Education Act for support in developing and implementing the training project described below.

SPECIFIC GOALS AND OBJECTIVES

The project will provide in-service training for elementary and secondary school teachers which will focus on (1) using oral communication to enhance the teaching/learning of mathematics and science; (2) using an integrative approach to teaching/learning in the mathematics and science curriculum; and (3) using content specific personnel from the areas of mathematics and science who also have expertise and training in the use of oral communication in the teaching/learning process.

Goals

This project has a single primary goal--to enhance student learning of mathematics and science in elementary and secondary schools. This goal is rooted in the fact that active learning using oral and written communication techniques for mathematics and science instruction is more effective than passive learning. Students remember about 10% of what they read, 20% of what they hear, 30% of what they see and 70% of what they write or speak about (Gagne, 1965). Thus this project places primary emphasis on using speaking to learn (as distinguished from learning to speak).

Corson (1988) contends that meaningful applications of oral communication techniques can provide practical solutions to many learning problems in elementary and secondary school mathematics and science.

Additional evidence is provided in a study of 28 elementary and secondary school teachers who received two training sessions in leading effective classroom discussions.

> Based on these results and due to the importance of oral communication in our society, more time should be relegated to increasing teachers' communication skills. Such training will stress the concerns of the recent National Assessment of Educational Progress. That is, such training can increase student's ability to interpret critically what they hear, increase their speaking skills, reduce teachers' inabilities to structure classroom discussions at high levels of thinking and increase the amount students learn. (Collins, 1987 b, p. 86)

A secondary goal of this project is to improve the oral communication skills of participating elementary and secondary school students and teachers. While the primary emphasis is on using oral communication to learn, an increased emphasis on oral communication training and experience for both students and teachers is a concomitant benefit.

The Task Force on Education for Economic Growth (Education Commission of the States) in its report, Action for Excellence (Brummett, 1987) recommends such training to enhance:

- The ability to engage critically and constructively in the exchange of ideas.
- The ability to answer and ask questions coherently and

concisely and to follow spoken instructions.

. The ability to identify and comprehend the main and subordinate ideas in discussion, and to report accurately what others have said.

. The ability to conceive and develop ideas about a topic for the purpose of speaking to a group; to choose and organize related ideas; to present them clearly in standard English.

Objectives

1. To develop and implement oral communication activities to enhance learning of course content in elementary and/or secondary school instruction in mathematics and science.

2. To provide assistance to participating elementary and/or secondary school teachers in improving their oral communication skills.

3. To improve elementary and/or secondary school instruction by providing teachers with materials suitable to instructing their students in oral communication skills.

After completing this project, participants should be able to:

. Discuss the importance of oral communication both as a teaching/learning tool and as a skill graduates need in their professional, civic and social endeavors.

. Discuss the need for additional oral communication activities in their classes.

. Discuss the benefits teachers gain from incorporating oral communication activities into their

classes.

. Design oral communication assignments to incorporate into their classes.

. Evaluate student oral communication activities both for learning mathematics and/or science and for adherence to accepted standards for competent communication.

. More effectively prepare and produce their own oral messages.

ACTIVITIES

Major activities to implement each of the three objectives are detailed below.

> Objective 1. To develop and implement oral communication activities to enhance learning of course content in elementary and/or secondary school instruction in mathematics and science.

A two-week workshop combined with periodic classroom visits by workshop staff will help achieve this objective. Selected elementary and secondary school mathematics and science teachers should work with project staff in planning the workshop. The workshop could be patterned after a workshop conducted by faculty at a Southeastern university (Summer 1989) for elementary and secondary school teachers on writing across the curriculum which included a 4 hour session on oral communication across the curriculum. While this workshop did not target science and

mathematics teachers specifically, it did focus on how teachers could utilize oral and written communication activities to enhance learning in their classes. The overwhelmingly positive evaluations from participants in the Summer, 1989 workshop provide strong support for workshops of this type (see Appendix A).

The workshop staff could present instructional material, lead discussions and activities and facilitate individual applications by participants on a wide variety of oral communication techniques to enhance student learning of mathematics and science. Specific examples of workshop activities for oral class presentations are provided below:

Oral Class Presentations to Enhance Learning of Math and Science

1. Provide coaching in:
   Delivery (both oral and non-verbal)
   Effective organization of the presentation
   (introduction, body, conclusion, etc.)
   Effective development and support of the presentation
   Methods of reducing speech fright
   Generating and adapting to immediate audience responses
   Using outlines and speaking outlines effectively
2. Help teachers plan oral presentations for the classroom.
3. Help teachers develop oral presentation techniques to be used in the classroom. Program personnel could utilize a number of training techniques to assist with

the topics listed above. These techniques include:

1. Analysis of face-to-face presentations and feedback by staff
2. Analysis by staff of audio and videotapes of oral performances
3. Provision for videotaping practice performances by students and analysis (by teachers) of the videotapes.

The following classroom exercise illustrates how speaking may be used to enhance the learning of science.

Speaking while discovering

Objective - To enhance the learning of scientific principles by verbalization during self-discovery thus forcing the student to mentally focus on observation and discovery.

Procedure - One student is chosen as "investigator" for the class. Using materials provided by the teacher, the "investigator" makes observations and attempts to discover scientific principles. This is done by trial and error while the "investigator" continually verbalizes his/her thoughts before the class. That is, he/she "thinks out loud" while making observations and experiments with the materials. This exercise may also be performed before the class by groups of two or three students serving as "investigators" where a dialogue might be generated during the discovery process, as well as within groups of two or three students wherein one serves as "investigator", verbalizing before the small group.

Sample Exercise

Objective - Minerals have various physical and chemical properties that may be used to classify them.

Materials - Several mineral specimens, a streak plate, a common nail, an eye-dropper, a bottle of vinegar, a magnet and a small hammer.

Procedure - Sarah is appointed "investigator" and positioned to be seen and heard by the class. Given the materials, she proceeds to make observations and to learn something about minerals. Her monologue might be as follows "I see some rocks, a nail, a magnet, a hammer, white plate and a bottle of something. One rock is red, one looks like metal and the other two are white. Let me see what happens with the magnet. The magnet sticks to the one that looks like metal, but not to the others. I don't know what the nail is for...let me see...if I scrape the metal rock nothing happens. If I scrape the red rock it scratches. So do the two white ones. The metal rock must be pretty hard and the other three must be softer. Let me try putting some of the stuff in the bottle on them. Nothing happens with the metal rock or the red rock, but one of the two white rocks makes bubbles when I put this stuff on it. I wonder what this stuff is? Well I haven't used the hammer yet. Let me see. If I try to break the metal rock...it's hard and won't break easily. The red rock breaks a little easier....one of the white rocks breaks easily and breaks with flat sides. The other white rock breaks very easily and makes a lot of powder. These

rocks are really different." At this point, perhaps, another student is chosen as "investigator" and is given the task of developing a plan by which the four minerals might be identified by their combination of properties.

Follow-up - The teacher may ask the observers for comments and/or suggestions to the "investigator" and/or may summarize and clarify the "investigator's" discoveries, introduce proper terminology and perhaps, assign the class a short speaking assignment entitled "How are minerals different?".

Rationale - The "investigator", being watched by the observers, is forced to focus on the problem. The observers' attention is focused on the "investigator" and novelty of listening to someone else "think aloud." They think of their own approach(es) to the problem and may have suggestions for the "investigator" for other things to try with the materials. They may even ask questions of the "investigator".

Speaking to solve math problems

Many math problems involve a series of steps to arrive at a solution. Students may experience difficulty discovering where to begin. Requiring students to discuss the relationships involved in the problem helps them gain a conceptual understanding before they become bogged down with rote application of numbers and formulas. Students could also be asked to explain an equation without using a memorized formula or to explain why a formula is appropriate to apply in solving a particular mathematical problem. Oral communication activities

can also be used to help students understand incorrect solutions to problems. Students could be asked to analyze their work and discuss where they made mistakes as well as possible corrections.

Classroom visits and a mid-term one-day workshop could be utilized to follow-up on workshop training and to assist participants in implementing, revising and evaluating the oral communication techniques used to enhance learning of science and mathematics. Workshop staff could observe teacher use of such activities and provide guidance on enhancing educational outcomes during classroom visits. The mid-term one-day workshop and classroom visits could facilitate the sharing of successful programs developed by participants with other elementary and secondary school teachers.

Objective 2. To provide assistance to elementary and/or secondary school teachers in improving their oral communication skills.

Participating teachers could be exposed to basic training in selected areas of oral communication. This basic training could prepare them to help train their students in using oral communication activities to enhance learning of science and mathematics. While the primary focus is on using oral communication to learn, teachers would gain valuable instruction (or refresher material) in improving their communication skills. The activity on oral presentations, detailed above, would be valuable in improving the communication skills of any teacher. An additional activity tailored to the teaching/learning of

mathematics and science (which would also help achieve objective 1) is detailed below.

Listening

1. Obtain and administer tests of effective listening.
2. Provide handouts and suggested readings on such areas as: bad habits of listeners, types of non-listeners, suggestions for improving listening, effects of poor listening, etc.
3. Provide help in diagnosing the major causes for the teacher's listening problems.
4. Train teachers in treatment methods designed to alleviate their specific listening problems i.e., effective note taking, accurate empathy, paraphrasing, parasupporting, anticipating major points, mentally recapitulating major points, identifying support material, etc.
5. Videotape teacher's listening behavior to identify nonverbal barriers that may be impeding effective listening.
6. Help teachers develop student listening techniques to enhance classroom learning.

Listening activities can be employed in any unit in science or mathematics to enhance both content mastery and listening skills. For example, in elementary school science, a series of students could present short talks on a specific method of staying healthy. Following the presentations, small groups of students will attempt to summarize each specific method

presented. Groups will present their summaries to the class and the class (or the teacher) will identify the group that demonstrated the best listening skills.

> Objective 3. To improve elementary and/or secondary school instruction by providing teachers with materials suitable to instructing their students in oral communication skills.

Training and materials in oral communication will enable participants to help their students improve their communication skills. As with objective 2, this is an important concomitant benefit of this project. The Commission on the University of the 21st Century recommends that we should have a curriculum at all educational levels "that helps students develop competence in public speaking, writing, listening and seeing the world around them" (p. 4). Quality instruction that participating teachers give their students to prepare them to use oral communication to learn science and/or mathematics should also help improve students' communication skills. The activities previously cited provide examples of such concomitant benefits. Two additional activities (which would also help achieve objectives 1 and 2) are detailed below.

<u>Critical Thinking</u>

1. Provide handouts, readings and lectures on key debating techniques.
2. Train teachers to help students prepare for classroom

debates.

3. Help teachers adapt debating techniques to their classroom needs.

4. Videotape practice and classroom debates and help students critique their critical thinking performance.

5. Train teachers to provide critiques for each classroom debate.

Classroom debates or other oral critical thinking activities can be applied to standards of learning (SOLS) in both mathematics and science. For example, SOLS for 2nd grade science may specify that: the student will describe the effect of seasonal changes on himself and his environment, the student will make inferences after observations of an object or event, the student will observe physical events and predict their outcomes. These could be partially achieved through critical thinking activities such as:

. Students are placed in small groups. One student identifies a cause and an effect relating to one of the SOLS. The group discusses what is the cause and what is the effect.

. From the discussion above, identify specific events for which students disagree about the cause(s) and the effect(s). Organize class debates on these areas in which students explain their position and think about their thinking.

. Place students in small groups. One student thinks

of a cause and an effect relating to one of the SOLS. The student names the effect and other students try to identify the cause. Have students explain their reasoning to the group. The group votes on the best reasoning to identify the cause. The student providing the best reasoning is allowed to name another effect for which other students will try to identify the cause, etc.

Math discovery

Students present brief oral reports defining or explaining mathematical concepts. For example, students could be asked to define circumference in their own words, explain how one finds the circumference, or explain the relationship of the circumference, the radius and the diameter. Oral communication activities such as these will help students understand course content and provide public speaking experience.

EVALUATION

Objectives could be evaluated by a variety of techniques including: staff evaluation, evaluation by elementary and secondary school teachers and students, evaluation by administrators and other program measures indicated below.

Objective 1. To develop and implement oral communication activities to enhance learning of course content in elementary and/or secondary school instruction in mathematics and science.

To measure success in achieving this objective seek evaluation from the participating school teachers regarding the workshop and their assessment of the value of oral communication activities in enhancing learning in their classes. Assess the number and types of oral communication activities employed by participants in their science and mathematics instruction. Seek evaluation from students as to the perceived impact on learning course content. Develop rigorous empirical measures to assess content learning for students using oral communication learning techniques. One approach would be to compare their learning outcomes with the content mastery of similar students taught by the same instructor without the use of oral communication learning techniques.

Objective 2. To provide assistance to participating elementary and/or secondary school teachers in improving their oral communication skills.

Seek evaluation from the participants relative to their perceived improvement in oral communication skills in areas such as improved delivery, improved listening, improved critical thinking skills, improved classroom presentation skills, improved clarity and organization, etc. Also quantify the number of participants who seek additional help with their oral communication skills from program personnel during the project. Utilize available measures of communication competency to assess actual improvement in oral communication skills.

Objective 3. To improve elementary and/or secondary school instruction by providing teachers with materials suitable to instructing their students in oral communication skills.

Seek evaluation from both the teachers and students regarding the improvement of students' oral communication skills as a result of this project. Utilize available measures of communication competency to assess actual improvement in oral communication skills.

CONCLUSION

Oral communication techniques to enhance learning across the curriculum can significantly improve instruction in elementary and secondary schools. Speech communication teachers should approach administrators and funding agencies for support in developing training programs to assist their colleagues in mathematics and science (and other subjects) in incorporating oral communication activities to enhance student learning of course content in these disciplines. This approach will place speech communication teachers in a leadership role in improving instruction in elementary and secondary schools. It may also motivate students using these techniques to elect additional training in speech communication classes.

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APPENDIX A. EVALUATION OF WAC SUMMER, 1989 WORKSHOP

COMMENTS FROM ENG 580 LANGUAGE AND LEARNING

PUBLIC SCHOOL TEACHERS' EVALUATIONS

"The instructors were warm, open, caring individuals who really wanted us to share and gain from this experience. They did not assume the role of lecturer but rather seemed to join us in a cooperative effort."

"Asking us on several occasions how we will modify our procedures to include this forced us to think in practical terms, which was the purpose of this course."

"I was particularly impressed with our leaders! I'm glad English people did not teach this class. I think we would have been more intimated if 'experts' had been chosen. I felt very comfortable because the teachers could share some of their frustrations and problems and because they did the exercises with us--They demonstrated and 'practiced what they preached.' The setting was good because of the large conference room for large groups with adjacent areas for small groups."

"The attitudes of and participation by the instructors were excellent. They were very patient and positive, even during trying times. I feel it was less threatening to have non-English professionals doing this, but I appreciated having English people in the group. I would have liked access to a dictionary and a Harbrace's Handbook."

"I really enjoyed this class--I did not think I would--esp. this time of year. The money helped get me here, but I'm glad I participated. Also got to know other members of our school

system much better. I think that's one of the pleasant side-effects of a class across the curriculum. Teachers were super (encouraging, helpful, supportive, clear, and very dedicated to their topic)."

"The teachers were enthusiastic and well prepared but not arrogant as is often the case. They are teachers just like us and did the assignments along with us. They were supportive, affable, and non-judgmental."

"I thought the class was well planned, well organized, and well handled. Instructors were most congenial and helpful. Good job!"

" I was encouraged by the fact that the two teachers conducting the class were not English teachers. I was also impressed by the fact that they completed all the writing assignments with us. I also think we had a good mixture of grade levels and subject areas."